UNCLASSIFIED

AD NUMBER

AD002010

NEW LIMITATION CHANGE

TO

Approved for public release, distribution unlimited

FROM

Distribution authorized to U.S. Gov't. agencies and their contractors; Foreign Government Information; DEC 1950. Other requests shall be referred to British Embassy, 3100 Massachusetts Avenue, NW, Washington, DC 20008.

AUTHORITY

DSTL, AB 15/1833, 8 Jun 2009

THIS PAGE IS UNCLASSIFIED

Reproduced by
Armed Services Technical Information Agency
DOCUMENT SERVICE CENTER
KNOTT BUILDING, DAYTON, 2, OHIO

AD-

2010

UNCLASSIFIED

AD No. 2410
ASTIA

A.E.R.E. I/R 638
COPY N

UNCLASSIFIED

ATOMIC ENERGY
RESEARCH ESTABLISHMENT

PREPARATION AND USE OF PILE-MADE GAMMA SOURCES FOR INDUSTRIAL RADIOGRAPHY

AN A. E. R. E. REPORT

BY

W.S. EASTWOOD

MINISTRY OF SUPPLY
HARWELL, BERKS.
DECEMBER, 1950.

UNCLASSIFIED

UNCLASSIFIED

PREPARATION AND USE OF PILE-MADE GAMMA SOURCES FOR INDUSTRIAL RADIOGRAPHY

by

W. S. Eastwood.

A.E.R.E. I/R. 638

(Based on papers read to the International Congress of Radiology and Association for Advancement of Science in Summer, 1950.)

CONTENTS

A.E.R.E. Harwell.

DECEMBER, 1950.

/Bl.

Crown copyright reserved.

HD 457

1. INTRODUCTION

This paper describes the work at Harwell using our Neutron Pile to make a range of gamma active sources for industrial radiography.

Hitherto the term gamma radiography has been confined to the use of the natural emitters whose energies are hard and very penetrating. It is our aim to produce inexpensively artificial sources covering a range of energies from 100 kilovolts to over 1 MeV. These will be complementary to X-ray tubes and will have the advantage of portability without inferior performance to that of a tube.

In selecting suitable elements for our sources we look for the following points.

A long half-life. - The activity of all these emitters decays exponentially at a rate characteristic of the element. This is conveniently expressed as a half-life which is the time within which the activity of a source falls to half its value. Half lives vary widely from seconds to many years, the usable extremes being typified by the natural emitters Radon (2.7 days) and Radium (1500 years). Half lives as short as Radon are inconvenient since a lot of activity is lost while transporting the source to the work and it is a nuisance calculating the exposures for such a rapidly dying source.

The sources selected have half lives of a month or two which gives a convenient working life. If shorter half lives are permitted a number of other sources could be included.

Energy

We would like, if we could, to find several materials emitting rays of say 100 - 200 KeV; 300 - 500 KeV; 1 MeV and 2 - 3 MeV. This would enable the radiographer to pick a source to give maximum contrast depending on the thickness and density of the work to be inspected.

Radioactive gamma emitters have an advantage over X-ray tubes in giving off rays of discrete energies rather than a continuous spectrum. This causes less soft scattering and avoids filtering problems. Gamma emitters sometimes have a complex spectrum however, consisting of a number of characteristic wavelengths. As a result of this it is impossible to predict from knowledge of a substance's gamma energies exactly how it will perform in radiography and experiment is necessary. This basic work of trying out the radiographic qualities of different sources has been done by the Isotope group at Harwell. It is of course clear that the dominating feature is the gamma that is hardest and the sources suitable for the low energy ranges must be free from shortwave components.

Good Nuclear and Physical Properties

Besides the half life and energy, it is essential that the substances have a large nuclear capture cross section for neutron irradiation.

Several materials have to be rejected on this score because they do not take up activity readily and the result is a low activity source which would need extravagantly long exposure times.

One could get over this by having a large sized source but such poor resolution would result that it would not be worth while.

2. LIST OF SUITABLE ISOTOPES

Figure 1 shows suitable sources grouped together under their gamma energy range as hard, medium and sort.

The hard class are all suitable for penetration of 2 inches and upwards of steel with slight individual advantages in the matter of long life, - speedy preparation - short exposure time etc.

In the medium energy class Iridium has by far the best characteristics as it activates rapidly to several curies giving a superior small active source to the Selenium and Hafnium. These substances are best for steel thicknesses of $\frac{1}{2}$ to 2 inches.

The low energy range is badly served. - We have found no convenient sources except possibly Ce - Pr^{144} a fission product which has recently been tried. Unfortunately, the wanted 220 kV radiation is masked by a harder 1.25 MeV which is found to make the source act as though it were one of this energy. The contrast to be expected from 220 kV does not appear.

3. SOURCE DETAILS

X-Radiographers are used to sources of radiation of several square millimetres area. To this end, we have standardised our source sizes as cylinders having diameter equal to length with dimensions 6 mm; 4 mm; 2 mm; and in certain cases 1 mm.

The activity required is usually in hundreds of millicuries, which means a high value of specific activity (mc/gram).

Fortunately materials like Iridium and Cobalt can be activated to several curies/gram, a figure in excess of natural radium.

For convenience of handling and labelling these sources have been enclosed in standard capsules of an aluminium alloy. Figure 2 shows the 2 mm; 4 mm; and 6 mm. sources before enclosure in the aluminium capsule and also a sealed and labelled capsule. These capsules are the standard holder for all our sources and serve to protect the beta emission from the source, identify the source size and type by a letter and serial number and also to provide a fixing tag to secure the source. In cases where the element is not metallic such as Eu_2O_3 - a powder pressing die has been used to compress a cylindrical pellet from the available oxide or salt. This is illustrated in Figure 3 which shows the die and a pair of forceps holding a pressed powder source.

At the present time no stock of ready-activated sources exists and irradiations are made in the Pile to a customer's order. This may take weeks or months depending on the activity required and the source size.

In the majority of cases the activity is acquired by neutron capture and sources of this type can be returned to Harwell for re-irradiation or "hotting-up" when their strength has decayed below a useful figure. In this way continuous service can be had from a source and many users keep two sources, one being activated and the other in use.

Activity of sources is measured by gamma ionisation methods and expressed in millicuries. This has the advantage that only a single figure need be quoted whereas if the ionising properties were given it is necessary to specify time and range, e.g. milli-röntgens/hour at 1 metre. Since millicuries are solely a disintegration rate - intercomparison of different kinds of sources is meaningless. Exposures are measured in "millicurie-hours" meaning so many hours exposure for a source strength of so many millicuries.

Owing to the complex gamma spectra of many of the elements their penetration characteristics are not predictable and we have prepared exposure density curves for the different types of source giving film density against exposure for a family of steel thicknesses.

The whole affair is reduced to the utmost simplicity by our issuing with every source a calibration chart showing the decay of millicuries with time - Figure 4.

This taken in conjunction with the exposure chart shows immediately the time of exposure needed for any given steel penetration.

Figure 5 shows an intercomparison of various different sources' exposure times to produce unity film density through different thicknesses of steel. All these graphs are supplied free to users in the form of data sheets for the principal sources we make.

The exposure graph does not show contrast directly, but may be inferred from the slopes of the curves. Penetrameter tests are so misleading that I prefer not to quote them but under suitable conditions figures of between 1 and 5 per cent can be obtained - results in fact comparable to those expected by X-ray methods.

The films used are the normal X-ray or fine grain X-ray types and we have found lead screens of .005 inches and .010 inches for front and back are slightly better than the rather thinner ones commercially available.

Figure 6 shows a panoramic test exposure in progress of the kind that led to the preparation of our exposure-density curves. The lead container is one of our own design having 4 inches of lead wall which can be used for a "projection" exposure or for panoramic withdrawal of the source on an articulated handling rod as shown. It will be noticed that steel slabs have been used rather than stepwedges as we have found results from these to be more consistent.

Figure 7 shows the container and handling tool with the front open for a "projection" exposure.

Lead containers are now being sold by four manufacturers suitable for holding our standard sources.

The sources in current use are cobalt 60, tantalum 182 and iridium 192. These have been found to combine the most desirable characteristics and are superior to the others listed. The Isotope Division at Harwell will be glad to advise on the use of our sources which have already found wide use in industry both here and on the Continent.

4. CIRCULATION

Mr. W. S. Eastwood (50)
Standard Circulation.

Isotope	Half Life	MeV Gamma Energies
Cobalt 60	5.3 y	1.1; 1.3;
Europium 154	5 y	.12; .34; .41; 1.2;
Tantalum 182	120 d	.15; .22; 1.13; 1.22;
Antimony 124	60 d	.12; .61; .65; .73; 1.7; 2.0;
Scandium 46	85 d	.88; 1.12;
Iridium 192	70 d	.30; .47; .60;
Selenium 75	127 d	.12; .14; .27; .4;
Hafnium 181	46 d	.52; .3;
Cerium 144	275 d	None
Praseodymium 144		1.25; 0.22;

FIG. I.

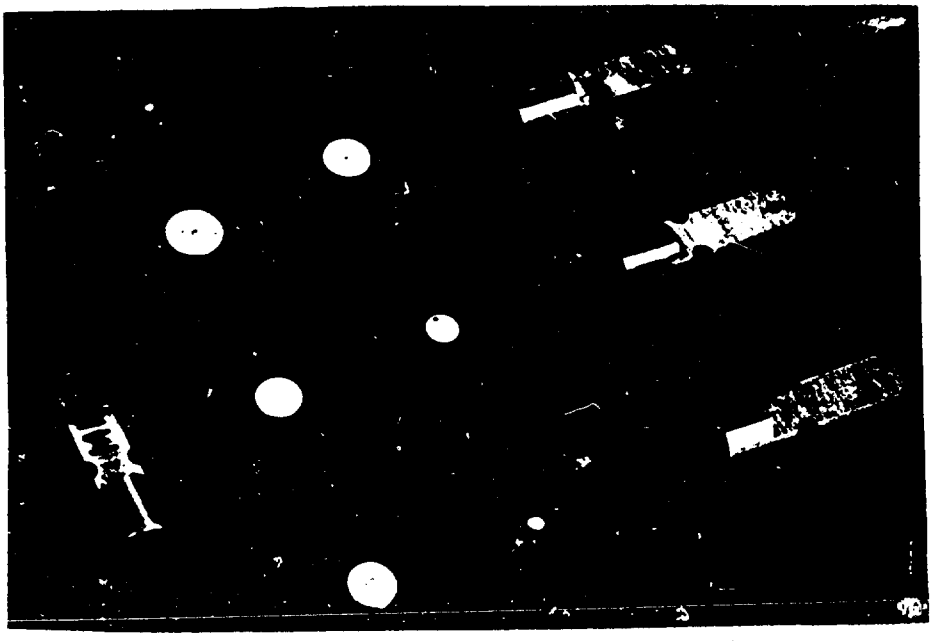


FIG. 2.

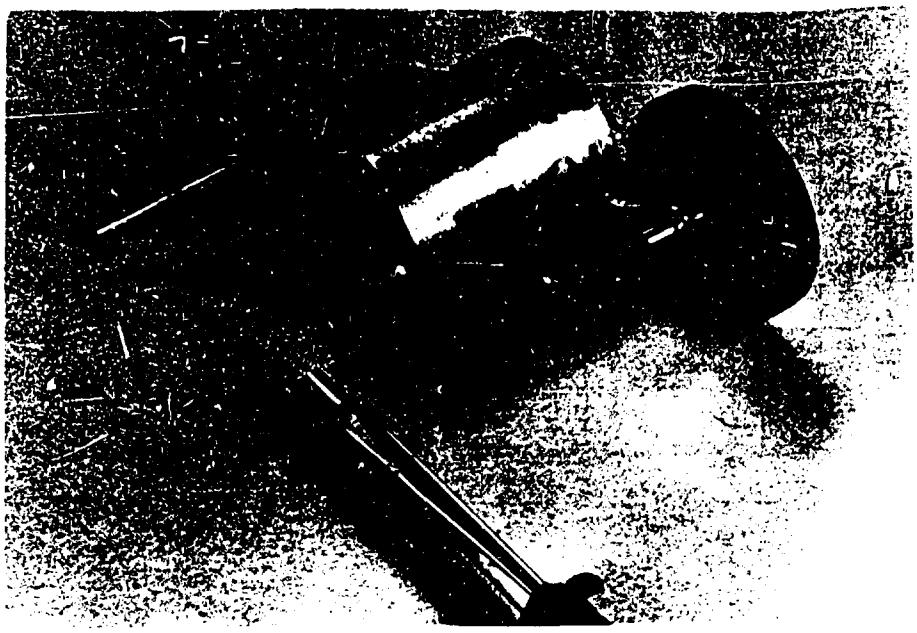


FIG. 3.

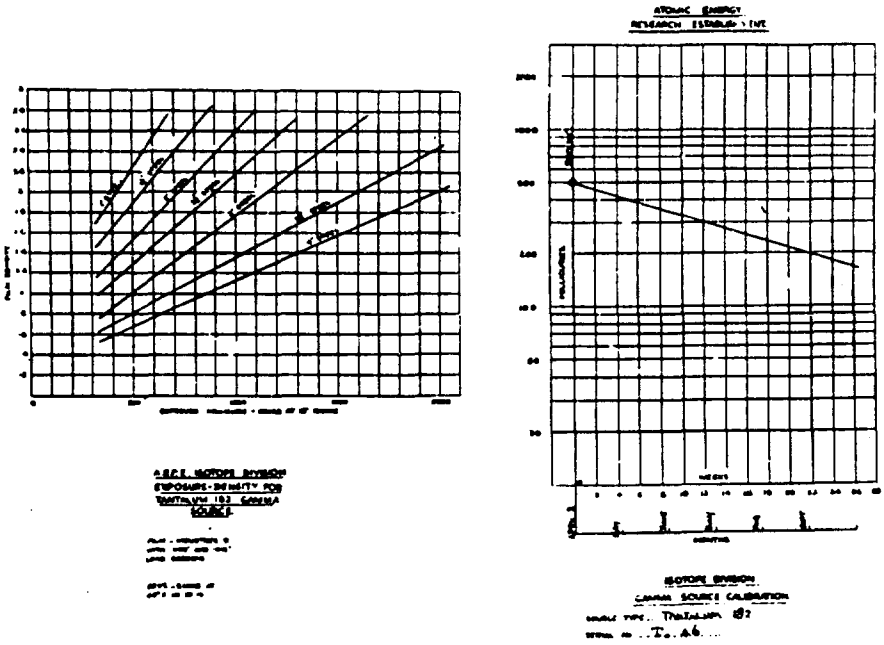


FIG. 4.

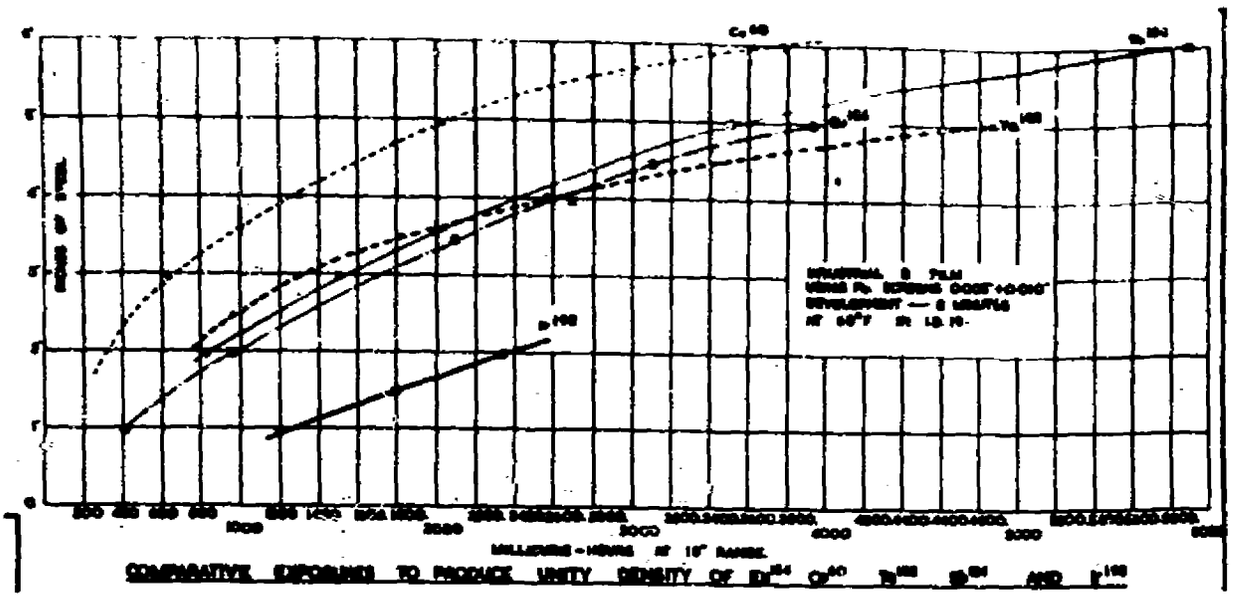


FIG. 5.

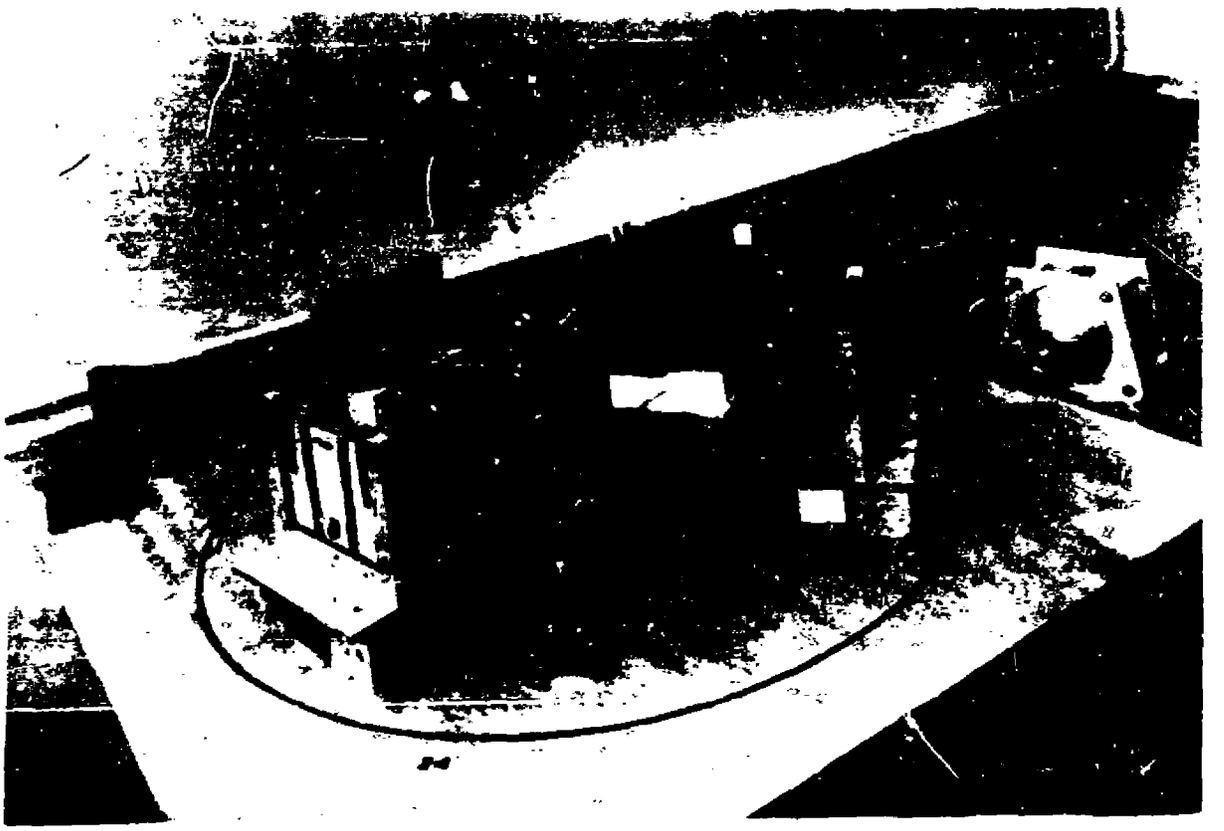
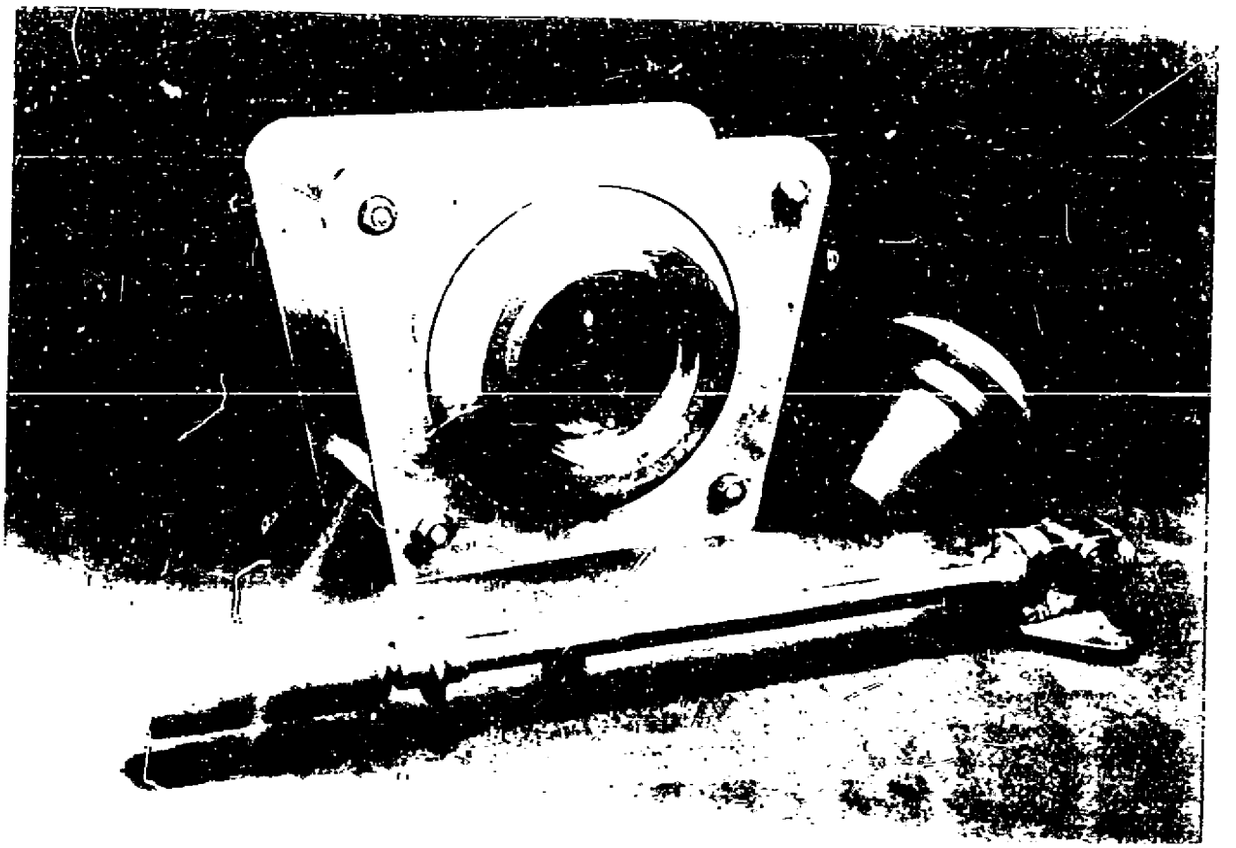


FIG. 6.



[dstl]

Information Centre
Knowledge Services
[dstl] Porton Down
Salisbury
Wilts
SP4 0JQ
22060-6218
Tel: 01980-613753
Fax 01980-613970

Defense Technical Information Center (DTIC)
8725 John J. Kingman Road, Suit 0944
Fort Belvoir, VA 22060-6218
U.S.A.

AD#: AD0002010

Date of Search: 8 Jun 2009

Record Summary: AB 15/1833
Title: Preparation and use of pile - made gamma sources for industrial radiography
Availability Open Document, Open Description, Normal Closure before FOI Act: 30 years
Former reference (Department) AERE I/R638
Held by The National Archives, Kew

This document is now available at the National Archives, Kew, Surrey, United Kingdom.

DTIC has checked the National Archives Catalogue website (http://www.nationalarchives.gov.uk) and found the document is available and releasable to the public.

Access to UK public records is governed by statute, namely the Public Records Act, 1958, and the Public Records Act, 1967.
The document has been released under the 30 year rule.
(The vast majority of records selected for permanent preservation are made available to the public when they are 30 years old. This is commonly referred to as the 30 year rule and was established by the Public Records Act of 1967).

This document may be treated as UNLIMITED.